

## INTRA-ABDOMINAL PRESSURE AND PERFUSION OF SPLANCHNIC ORGANS FOLLOWING MAJOR SURGERIES IN THE ABDOMINAL CAVITY

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### Abstract

The aim of our work was to evaluate the incidence of intra-abdominal hypertension and related hypoperfusion of splanchnic organs following major surgeries. The study included patients undergoing elective intra-abdominal surgery with scheduled surgery duration longer than two hours. The postoperative measurement of intra-abdominal pressure (IAP), gastric tonometry (GT), and blood gases was conducted at times T0, T1, T6, T12, T18, and T24. Also, intra-abdominal perfusion pressure (APP) and CO<sub>2</sub> gap were calculated. Indocyanine green clearance (ICG-PDR) was measured non-invasively at times T1 and T6. The study included 13 patients (9 men and 4 women) with an average age of 69 (35; 78), who underwent non-complicated surgeries in combined anaesthesia. Postoperative analgesia was provided by means of epidural catheter. The average IAP upon intensive care reception was 8 (1; 18) mm Hg, and in the course of the study it did not show any significant change. Only three patients (23 %) were recorded as having IAP higher than 12 mm Hg at least once in the course of the study. IAP higher than 25 mm Hg was not recorded at all. The average APP at time T0 was 87 (62; 105) mm Hg, and in the course of the study it showed a significant decrease ( $p < 0.001$ ). The average CO<sub>2</sub> gap was -0.1 (-1; 2.9) kPa and it showed no significant change. Only two patients were recorded as having pathological value of ICG-PDR lower than 18 %/min. All patients underwent intensive care treatment without any significant complications, with the exception of a patient who died of malignant arrhythmia on the fourth postoperative day. According to our experience, significant rise in IAP following major intra-abdominal surgeries is very rare. Similarly rare is hypoperfusion of gastric mucosa and liver hypofunction.

### Key words

Intra-abdominal pressure, Gastric tonometry, ICG clearance

### Abbreviations used

IAP, intra-abdominal pressure; GT, gastric tonometry; APP, abdominal perfusion pressure; ICG-PDR, indocyanine green clearance; IAH, intra-abdominal hypertension; ACS, abdominal compartment syndrome; MAP, mean arterial pressure

## INTRODUCTION

In spontaneously ventilating patients, normal intra-abdominal pressure (IAP) is about 0 mm Hg (1). Intra-abdominal hypertension (IAH) is defined as IAP higher than 12–20 mm Hg (2). In recent IAH diagnostics, there has been a distinct prevalence of lower values (values higher than 12 mm Hg in inert patients and values higher than 15 mm Hg in surgical patients) because these have been proved as being boundary values in mortality prediction (2, 3, 4). The abdominal compartment syndrome (ACS) is usually defined as IAP higher than 20–25 mm Hg, combined with haemodynamic instability or another organ dysfunction.

Prevalence of IAH depends on chosen criteria and types of patients and according to various studies it ranges between 18–81 %. Prevalence of ACS ranges between 2–36 % (2).

IAP exceeding 10 mm Hg already has a number of negative pathophysiological effects on perfusion and function of splanchnic organs (5). Pressures higher than 15 mm Hg significantly decrease thoracic compliance and pressures higher than 20 mm Hg lead to circulatory instability and oliguria (4, 6–8). Higher intra-abdominal pressure is an independent factor increasing morbidity and mortality in surgical patients (9, 10). Recent studies on the pathophysiology of splanchnic hypoperfusion stress the decrease of abdominal perfusion pressure (APP), which is the difference between mean arterial pressure (MAP) and IAP. Maintaining APP higher than 60 mm Hg probably prevents the expansion of hypoperfusion even in pathologically higher IAP (11, 12). Intervention is recommended at APP falling below 50 mm Hg.

Gastric tonometry (GT) and monitoring of the plasma disappearance rate (ICG – POR) with the use of pulse spectrophotometry are relatively non-invasive methods providing global information about the perfusion (energetic balance) of gastric mucosa (GT) and blood circulation and function of the liver (ACG – POR) (13, 14). Pathological values of GT and ICG – POR represent prognostic figures in the survival probabilities of critical patients (15, 16). Both GT and IAH are considered to be timely indicators of potential splanchnic catastrophe (17).

Major intra-abdominal surgery (defined usually as longer than two hours) represents a relatively high risk of possible complications (18). The pathogenesis of postoperational complications is multifactorial, with IAH being one of the factors. In our study we focused on the prevalence of IAH and splanchnic perfusion dysfunctions (GT, ICG – POR) in patients following major intra-abdominal surgeries.

## MATERIAL AND METHODS

The study included patients undergoing elective intra-abdominal surgery with scheduled surgery duration of two hours and longer. The procedures scheduled were either GIT anastomosis or pancreas surgery. In each patient, an epidural catheter was located shortly prior to the surgery. Following total anaesthesia, the patients received central venous catheter, arterial catheter, urinary catheter and tonometric gastric probe (Tonometrics TM Catheter, Tono – 16F, Datex, Ohmeda, Finland). The localisation

of the probe was palpated in the course of the operation. Following the surgery, all patients were extubated in the operating room, received in the intensive care unit, and monitored for at least 24 hours. Postoperational analgesia was provided with the use of epidural catheter.

IAP was measured in the urinary bladder by a modified method according to *Iberti (Fig. 1 (19))*. After the stoppage of the urine outflow by the catheter, the urinary bladder was filled with 50 ml of physiological solution and IAP was measured, following the 18 G needle insertion, via the aspiration port of the urinary catheter by means of a water column. The zero level was set at symphysis pubis. The initial measurement was done upon the patient's admission in the intensive care unit and then again 1, 6, 12, 18, and 24 hours after the admission, and the values were converted into mm Hg ( $\text{cm H}_2\text{O}/1,36 = \text{mm Hg}$ ). Normal IAP was set at values lower than 12 mm Hg; values higher than 20 mm Hg were considered as high IAH (2). At the times of IAP measurement, we monitored the median of MAP and calculated APP.

Gastric tonometry was automatically monitored using a tonometric module (Datex Ohmeda, Finland) every ten minutes (20). Samples of arterial blood gases were analysed at the same intervals as IAP. Also  $\text{CO}_2$  gap was calculated ( $\text{pgCO}_2\text{c};\text{-paCO}_2$ ). The  $\text{CO}_2$  gap of 1 kPa was regarded as a normal value. The patients were not routinely given H2 blockers or proton pump blockers and the probe was not switched on for active suction.

The perfusion of the liver and the extractive function of the hepatocytes were monitored for ICG - POR, which was measured noninvasively using a photometric device LiMON (Pu/sion Medica/ Systems, Germany) 1 and 6 hours after the admission in intensive care. For the determination of ICG - POR, a small amount of the dye was injected into the central venous catheter (21). The physiological value was considered at 18 %/ min. At the same time, hepatic functions were observed according to the phylogenesis of bilirubin concentration and prothrombin time. All patients were monitored for diuresis at six-hour intervals. Diuresis smaller than 200 ml per six hours was considered as oliguria.

The data given are stated as median figures.

## RESULTS

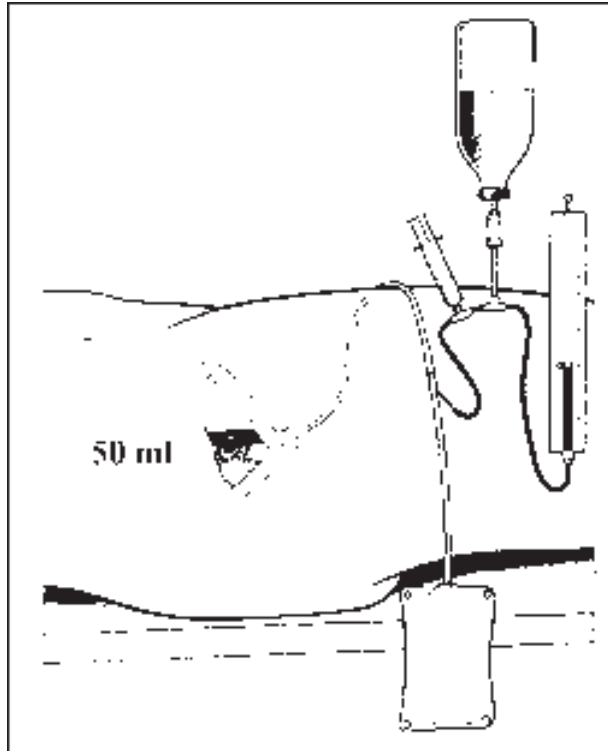
The study included 13 patients (9 men and 4 women) with an average age of 68 (35–78), who underwent non-complicated surgeries lasting longer than two hours in combined total and epidural anaesthesia.

Demographic data and types of surgeries are featured in *Table 1*. Median values of IAP, APP, and  $\text{CO}_2$  gap in the course of the study are featured in *Table 2*.

Only three patients (23 %) were recorded as having IAP higher than 12 mm Hg at least once in the course of the study. Two of these three patients underwent palliative ileorectoanastomosis with the tumour left *in situ*. The third patient after hemicolectomy showed two IAP values increased at 14 and 15 mm Hg at times T0 and T24 respectively. High IAP, defined as IAP higher than 20 mm Hg, was not detected in any patient.

In the course of the study, APP showed significant decrease ( $p < 0.001$ ). Three patients were given small doses of catecholamine.  $\text{CO}_2$  gap values were obtained only in 12 patients (in one patient arterial access was impossible).  $\text{CO}_2$  gaps higher than 1 kPa were measured on the whole eight times in five patients with the respective IAP highest at 10 mm Hg (except for patient 12 after palliative surgery).

One hour after the admission in intensive care, at time T1, the measurement failed in four patients and at time T6 in two patients. Only two patients were recorded as having pathological values of ICG - PDR. In patient 11 the value of 8.9 %/min



*Fig. 1*  
IAP measurement diagram

increased to 20.7 %/min and in patient 8 the value decreased from 12.1 %/min to 7.2 %/min. Both these patients were recorded as having IAP, bilirubin level, and values of hepatic enzymes within the normal scale.

Oliguria was detected in three patients, of which in two only temporarily, in the course of one six-hour interval with a consequent adjustment. Only patient 12 suffered from oliguria in the course of two intervals with IAP increased to 16 mm Hg, CO<sub>2</sub> gap to 1.4 kPa, and APP decreased to 61 mm Hg.

The following surgical complications were recorded: wound dehiscence (patient 2 was recorded as having IAH) and wound abscess (patient 9 was recorded as having normal IAP). Peristaltic activity was restored in all patients within three days after the surgery at the latest, with the exception of patient 12 after palliative ileorectostomy, where intestinal paralysis lasted eight days. All patients underwent intensive care treatment without any significant complications, with the exception of a patient who died of malignant arrhythmia on the fourth postoperative day. The average stay in intensive care was 4 days (2-10) and the patients were discharged after 12 (9-13) days.

*Table 1*  
Demographic data and types of surgeries

Patient number	Age	Sex	Type of surgery
1	59	M	resectio recti
2	72	M	hemicolectomia I. dx.
3	71	M	ileorectoanastomosis – palliation
4	70	M	hemicolectomia I. dx.
5	48	M	hemicolectomia I. sin.
6	73	M	resectio sigmoidei
7	77	F	hemicolectomia I. dx., CHCE
8	78	F	hemicolectomia I. sin.
9	55	M	op. sec. Whipple
10	69	M	op. sec. Miles
11	50	F	resectio caudae pancreatis, splenectomia
12	64	F	ileorectoanastomosis – palliation
13	35	M	proctocolectomia subtotalis

*Table 2*  
Median values of IAP (mm Hg), APP (mm Hg), and CO<sub>2</sub> gap (kPa) in the course of the study

	Intensive care admission	T1	T6	T12	T18	T24	P
IAP	8 (1; 14)	9 (3; 18)	7 (2; 16)	8 (1; 16)	9 (3; 16)	9 (4; 15)	n. s.
APP	87 (62; 105)	87 (66;101)	69 (53; 91)	64 (51; 77)	68 (55; 81)	72 (49; 84)	<0.001
CO <sub>2</sub> gap	0 (-0.7; 2.9)	0,3 (-0.4; 1.9)	0,8 (-0.4; 1.9)	0,6 (-0.9; 1.8)	0,7 (-0.2; 2.2)	0,4 (-1; 1.9)	n. s.

## DISCUSSION

In our study, we noted a low occurrence of IAH. In patients following major surgeries, IAP higher than 12 mm Hg within 24 hours after the surgery was recorded only in one patient. And even in this particular patient, IAP did not exceed 15 mm Hg, which is considered by some authors as the upper bound of the norm for surgical patients. Considering the possibility of an error of small numbers, we are of the opinion that the low incidence of IAH could have been influenced by the fact that all patients included in the study were spontaneously ventilating patients with good analgesia.

Measurement was done by means of a method standardly used in intensive care (22). The use of water column provides reliable results and the value in cm is converted into mm Hg.

Abdominal perfusion pressure (APP) significantly decreased in the course of the study, despite the fact that clinically significant hypertension was in three cases treated by the use of liquids and small doses of catecholamine. The reason could be in latent hypovolemia potentiated by epidural analgesia. Only once did APP decrease below 50 mm Hg, which is regarded as a dangerous level. The respective patient showed normal values of IAP and CO<sub>2</sub> gap, while his ACG - POR showed a pathological value.

Verging pathological values of CO<sub>2</sub> gap were rare. Significantly pathological values higher than 2.5 kPa, which, according to some studies, are significant for mortality prediction, were recorded only once (15). CO<sub>2</sub> gap values did not correlate with IAP. The fact that IAP did not reach significantly pathological values is a possible reason why the parameters in this study did not correlate unlike in other studies (17, 24). Moreover, a significant dependence between IAP and gastric hypoperfusion has not been unambiguously acknowledged by all authors (4).

The values of ICG - POR ranged within the boundaries of normal values, with exceptions. In one patient, the values were adjusted 6 hours after the surgery. In another patient, the pathological value of 7.2 %/min progressed towards critically low values associated unambiguously with 100 % mortality in critical patients (25). The significance of detected pathological values in these two patients remains unclear regarding the fact that hepatic tests were normal and the postoperational course was without complications. Similarly to other authors, we did not record any relationship between IAP and ICG - POR. Failure of the ICG - POR measurement was rather frequent (a total of 6 times). Especially in the course of the immediate postoperational period, in which the measurement failed 4 times (at time T1), it may have been caused by shiver and peripheral hypoperfusion following the transport from the operating room.

The patients were not specifically observed for renal dysfunction, only monitored for diuresis. The occurrence of oliguria was rather rare.

Three patients were given small doses of catecholamine in the course of the study. In most studies, noradrenaline had a positive influence on gastric perfusion; the effect of dopamine was not unambiguously proved (27). We are of the opinion that two postoperational complications (wound dehiscence and paralytic ileus in a patient with palliative surgery) could have been related to higher IAP. The other two complications (wound abscess and malignant arrhythmia) were detected in patients showing normal values.

## CONCLUSION

The results of our study show that patients following major non-complicated intra-abdominal surgeries are rarely detected as having pathological values of IAP.

Similarly rare is hypoperfusion of gastric mucosa monitored by gastric tonometry and hypoperfusion of the liver evaluated with the use of ICG - POR. Despite the data obtained, we do not consider the IAP measurement following surgeries in the abdominal cavity as purposeless, as IAP values can be obtained in a relatively easy and non-invasive way. A potentially higher value represents a warning signal, which is not to be ignored by the clinician.

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## INTRAABDOMINÁLNÍ TLAK A PERFUZE SPLANCHNICKÝCH ORGÁNŮ PO VELKÝCH VÝKONECH V DUTINĚ BŘIŠNÍ

### Souhrn

Cílem naší práce je posouzení incidence intraabdominální hypertenze a s ní související hypoperfuze splanchnických orgánů po velkých nitrobřišních výkonech. Do studie byli zařazeni pacienti podstupující elektivní nitrobřišní operaci s plánovanou délkou výkonu více než 2 hodiny. Pooperačně byly měřeny v čase T0 a dále pak v časech T1, T6, T12, T18 a T24 nitrobřišní tlak (IAP), gastrická tonometrie (GT) a krevní plyny. Byl vypočten intraabdominální perfuzní tlak (APP) a CO<sub>2</sub> gap. Clearance indocyaninové zeleně (ICG-PDR) byla neinvazivně měřena v T1 a T6. Do studie bylo zařazeno 13 pacientů (9 mužů, 4 ženy) s průměrným věkem 69 (35; 78) let, kteří podstoupili nekomplikovanou operaci v kombinované anestezii. Pooperační analgezie byla zajištěna epidurálním katetrem. Při přijetí na JIP byl průměrný IAP 8 (1; 18) mm Hg a významně se nezměnil v průběhu studie. Pouze u 3 pacientů (23 %) byl IAP zvýšen nad 12 mm Hg alespoň jednou v průběhu studie; nezaznamenali jsme IAP > 25 mm Hg. Průměrný APP v T0 byl 87 (62; 105) mm Hg a během studie došlo k významnému poklesu (p < 0,001). CO<sub>2</sub> gap byl v průměru -0,1 (-1; 2,9) kPa a významně se neměnil. Pouze 2 nemocní měli patologickou hodnotu ICG-PDR < 18 %/min. Pobyť všech nemocných na JIP byl bez závažných komplikací s výjimkou pacienta, který zemřel na maligní arytmii 4. pooperační den. Dle našich zkušeností dochází po velkých nitrobřišních operacích jen vzácně k významnému zvýšení IAP. Stejně i hypoperfuze žaludeční sliznice či hypofunkce jater je raritním nálezem.

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